Directorate of
Intelligence

Secret

25X1

The Soviet Oil Refining Industry: Lagging Adjustments to Changing Requirements

25X1

A Research Paper

Secret

SOV 85-10065
IA 85-10036
April 1985

Copy 461

Page Denied

Directorate of Intelligence

Secret [redacted] 25X1

The Soviet Oil Refining Industry: Lagging Adjustments to Changing Requirements [redacted] 25X1

A Research Paper

This paper was prepared by the Resource Management Branch, Office of Soviet Analysis, with technical support from [redacted] 25X1
[redacted] Office of Imagery Analysis. 25X1
Comments and queries are welcome and may be directed to the Chief, Economic Performance Division, SOVA [redacted] 25X1

Secret
SOV 85-10065
IA 85-10036
April 1985

Sanitized Copy Approved for Release 2011/01/31 : CIA-RDP86T00591R000200190003-0

The Soviet Oil Refining Industry: Lagging Adjustments to Changing Requirements [redacted] 25X1

Summary

Information available as of 31 December 1984 was used in this report.

With domestic oil production leveling off at about 12.2 million barrels per day (b/d) in 1984 and then possibly declining to 11-12 million b/d by 1990, the USSR can no longer rely as heavily as in the past on expansion of primary refining capacity to satisfy the demand for refined products. Growing requirements for high-quality light products (gasoline, jet fuel, diesel fuel) will call for a marked shift in refinery yields and greater processing flexibility. A substantially larger portion of heavy fuel oil (mazut), now used primarily for electric power generation and in industrial boilers, will have to be converted to light products by processing in secondary refining units. [redacted] 25X1

The long-run trend in the refinery product mix, however, has run counter to the direction the Soviets would like to take:
- The average yield of heavy fuel oil from a barrel of crude oil has climbed from about 35 percent in 1970 to about 40 percent in 1983.
- Since 1970 the yield of gasoline and diesel fuel has dropped slightly and was less than 40 percent in 1983. [redacted] 25X1

As a result of a lengthy examination of [redacted] Soviet refineries, we estimate that: 25X1
- In mid-1984 the 50 major refineries in operation had a primary distillation capacity of about 10.5 million barrels per operating or stream day (b/sd).
- Secondary processing capacity in 1983 (excluding thermal cracking, which produces lower quality products) amounted to more than 3 million b/sd.
- The USSR's secondary processing capacity in 1983 was equivalent to about 30 percent of total primary distillation capacity, compared with about 120 percent in the United States. [redacted] 25X1

During the past 15 years, the USSR has made considerable progress in upgrading its refinery technology. Unit capacities have increased markedly in primary distillation as the Soviets followed Western developments, although with an appreciable lag. In secondary refining, an emphasis on catalytic reforming and hydrogen treating has paved the way for an improvement in the quality of refined products. At the same time, the increase in catalytic-cracking and hydrocracking capacity, which would raise the yield of light products, has been small. [redacted] 25X1

SOV 85-10065
IA 85-10036
April 1985

25X1

The shortfall in installing secondary processing facilities in oil refineries has not had serious consequences so far. This is because shortfalls in the production of coal and delays in commissioning nuclear power plants and building gas pipelines to industrial sites have kept the demand for heavy fuel oil at a higher level than the Soviets anticipated. By 1990, however, we expect the demand for light products in the Soviet Union to be 1 million b/d higher than in 1980. Because only about 90,000 b/sd of catalytic-cracking capacity has been added since 1980, we judge that continued delays in commissioning catalytic crackers and hydrocrackers would result in growing shortages of light products in the USSR. 25X1

Changing the product mix of Soviet refineries to meet prospective demand for light products will require large capital expenditures and an accelerated effort to improve technology, possibly involving substantial acquisitions of equipment and technology from the West. Several options are available to the Soviets:

- They could import from the West 15 catalytic-cracking units—or a combination of catalytic-cracking and hydrocracking units—on a turn-key basis.
- They could buy one or two Western catalytic-cracking or hydrocracking units and concurrently build domestic units to increase secondary processing capacity.
- Alternatively, they could install unsophisticated thermal-cracking and delayed coking equipment (which Soviet industry can manufacture) to increase the yield of light products.
- If expansion of cracking facilities is delayed, they might consider importing light products from nonsocialist countries. 25X1

Each course of action has advantages and disadvantages. Importing all needed cracking units from the West would be fastest and technically most efficient but would require hard currency outlays of at least $1 billion. Importing a few cracking units and attempting to build sufficient additional domestic units would probably not increase capacity enough to meet 1990 needs for light products. Relying on installation of more thermal cracking and delayed coking units would require upgrading—in catalytic-treating units—the poorer quality products derived. The product yields and operating efficiencies would be lower than those obtainable from the other options but so would the costs. As for relying on Western refineries as a source of light products, we doubt that the USSR would be willing to accept this kind of dependence for strategically important products such as gasoline, diesel fuel, and kerosene. In sum, whatever the Soviets do, implementation will be time consuming and expensive, but some Western involvement will almost certainly be required if the USSR is to obtain a fuel mix suitable for future needs. 25X1

Contents

Appendixes

25X1

Oil Refinery Operations in a Nutshell

A modern petroleum refinery consists of a number of processing units designed for physical and chemical conversion of crude oil into various petroleum products in volumes roughly proportionate to market demand. Refineries differ in the types of crude oil processed and the mix of products.

The first and fundamental step in refining is distillation, which accomplishes the rough separation of crude oil molecules according to their size and weight by the use of heat. Primary distillation takes place in towers (fractionating units) as high as 30 meters. These towers contain perforated trays, set one above the other. Crude oil is heated to more than 370°C and pumped into these units in vaporized form. The lighter fractions of the vapor rise highest in the tower, and, as the vertically stratified vapors cool and condense, they are collected in the trays at different levels. The resulting light, medium, and heavy products are piped separately to other parts of the refinery.

Distillation can separate crude oil into its fractions, but it cannot produce more of a particular fraction than nature put into the crude oil. But the demand for various products does not necessarily conform with the proportions found in the crude oil. Refineries, however, can resort to secondary processes to produce additional amounts of gasoline and other high-quality fuels and to upgrade product quality.

To increase the yield of light products by secondary processing, the heavier hydrocarbon molecules are "cracked" into smaller molecules by heat and pressure, often in the presence of a catalyst. The most efficient processes for such cracking operations are catalytic cracking and hydrocracking. Thermal cracking, visbreaking, and delayed coking also perform the same function without the use of catalysts, but provide lower rates of conversion and lower product quality than are obtainable with catalytic cracking and hydrocracking. 25X1 25X1

The quality of various products can be improved by such processes as catalytic reforming and hydrogen treating. Catalytic reforming provides a high-octane motor gasoline and/or aromatic hydrocarbons—benzene, toluene, xylene—for chemical uses. Hydrogen treating is used primarily to lower the sulfur content of jet fuel and diesel fuel and to prepare stocks for manufacture of lubricating oil. Unlike the cracking processes, however, these processes only improve the quality of distillation products—they do not increase the yield of light products from a barrel of crude oil. 25X1 25X1

A complete refining installation will include an array of nonprocessing facilities: adequate tankage for storing crude oil, as well as intermediate and finished products; a dependable source of electric power and steam for use in refining; materials-handling equipment; workshops and supplies for maintaining round-the-clock operation; waste-disposal and water-treating and cooling equipment; and product blending facilities. 25X1 25X1

25X1

The Soviet Oil Refining Industry: Lagging Adjustments to Changing Requirements

25X1

Introduction

In the refining industry the basic yield of residual fuel oil from primary distillation of crude oil is about 45 percent. Because the growth in petroleum product consumption has been driven primarily by the demand for gasoline and middle distillates (diesel fuel, gas oil), refiners have been upgrading their plants to convert residuals to lighter products. (See inset for explanation of refinery operations and appendix A for definitions of the major refining processes.) At the present time the average worldwide yield of residual fuel after primary and secondary processing has been reduced to 25 percent. In the United States, where gasoline accounts for about 45 percent of total output, the yield of residual fuel has been lowered to less than 10 percent.

The USSR, however, produces a rather simple mix of petroleum products, reflecting a relatively undeveloped domestic market and a technological level in refining that lags that in the West. After primary and secondary processing, the gasoline yield is only about 17 percent, and 35 to 40 percent of the yield of petroleum products still is in the form of residual fuel oil (mazut).

Until the mid-1960s Soviet priorities were directed toward expansion of basic refining operations (primary distillation) to handle the rising volume of crude oil being produced. Since then, efforts have been made to intensify processing with secondary units and to upgrade product quality. Currently, the Soviets want to build combination systems employing catalytic-processing units to reduce the yield of mazut and increase the yield of high-quality light products.

This paper outlines the problems with the product mix, provides an overview of recent developments in Soviet refining capacity and technology, and assesses the options available for expanding the technological base of the refining industry during the remainder of the 1980s.

Problems With the Product Mix

Until the late 1970s the USSR was able to increase the output of gasoline and other light products by producing more crude oil and building more primary distillation units in refineries to process it. Catalytic-reforming and hydrotreating units were installed in refineries to upgrade the quality of these light products. The recent decline in crude oil production (from about 12.3 million b/d in 1983 to 12.2 million b/d in 1984) and the rise in the share of heavier crudes in total oil production are now foreclosing the option of installing additional primary units to increase light-product output. The rate of increase in the output of petroleum products is declining sharply (see table 1); and, if our projection of crude oil production for 1990—11-12 million b/d—is correct,[1] product output also is likely to decline by the end of the 1980s. 25X1

25X1

As demand for high-quality light products increases, the need for secondary processing units to reduce the high yields of mazut will rise. A significant shortfall in plans for the construction of such units has occurred during the 1981-85 plan period. According to a 1982 *Izvestiya* article, the share of oil refined using "deep" refining processes has been decreasing. As a result, larger volumes of mazut are available and continue to be used as a boiler fuel at many power plants and industrial facilities where coal and natural gas were to have been substituted. Another Soviet newspaper reported that during the first eight months of 1982 the refining industry produced millions of tons more mazut than planned. 25X1

25X1

25X1

25X1

25X1

Table 1
USSR:
Estimated Output of Petroleum Products, 1960-83

	1960	1965	1970	1975	1978	1980	1981	1982	1983
	Thousand barrels/day								
Total [a]	**2,275**	**3,440**	**5,035**	**7,040**	**8,090**	**8,500**	**8,665**	**8,705**	**8,710**
Gasoline	470	670	975	1,260	1,390	1,440	1,470	1,485	1,495
Kerosene	280	295	405	505	555	565	575	565	565
Diesel fuel	560	945	1,290	1,675	1,930	2,050	2,105	2,120	2,135
Other light products	55	75	110	205	245	280	290	315	315
Lubricating oil	100	135	160	190	215	220	225	230	230
Fuel oil	730	1,215	1,910	2,855	3,360	3,595	3,630	3,630	3,610
Other residuals	80	105	185	350	395	350	370	360	360
	Percent of total								
Total [a]	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Gasoline	20.7	19.5	19.4	17.9	17.2	16.9	17.0	17.1	17.2
Kerosene	12.3	8.6	8.0	7.2	6.9	6.7	6.6	6.5	6.5
Diesel fuel	24.6	27.5	25.6	23.8	23.9	24.1	24.3	24.4	24.5
Other light products	2.4	2.2	2.2	2.9	3.0	3.3	3.3	3.6	3.6
Lubricating oil	4.4	3.9	3.2	2.7	2.6	2.6	2.6	2.6	2.6
Fuel oil	32.1	35.3	37.9	40.5	41.5	42.3	41.9	41.7	41.5
Other residuals	3.5	3.0	3.7	5.0	4.9	4.1	4.3	4.1	4.1

[a] Total products shown in this table exclude gas and losses, which amount to about 8 percent of the crude oil charge.

25X1

Indeed, the long-run trend in the distribution of refinery products has run counter to the direction the Soviets would like to take. The average yield of mazut from a barrel of crude oil input to the refining process has continued to increase, rising from about 35 percent in 1970 to about 40 percent in 1983, despite Soviet plans and proclamations aimed at reducing its share.[2] Meanwhile, the yield of all light products from a barrel of crude oil has averaged 45 to 50 percent since 1970, with the yield of gasoline remaining at a relatively low 17 percent. With the addition of considerable catalytic-reforming capacity since 1970, the octane rating of Soviet gasoline has increased substantially, however.

The use of diesel fuel also will increase sharply. Diesel engine vehicles in the USSR represent about one-fourth of the Soviet motor vehicle inventory, and having more diesel engines in the truck inventory is an important element of Moscow's energy plans. The estimated yield of diesel fuel from a barrel of crude has averaged 22 percent during the past decade, although the quality has improved as the Soviets have installed numerous hydrotreating units to produce a low-sulfur product. Because of technical limitations on increasing yields of light products from primary distillation, the output of gasoline and diesel fuel is increased by utilizing the various cracking processes. In recent months Soviet technical journals have reported that the growing demand for diesel fuel and 25X1

[2] The product shares in the text are percentages of the total crude oil charge. The shares in table 1 relate the output of each product to a "net" barrel of crude oil; that is, after deduction of approximately 8 percent for gas and losses.

25X1

the consequent possible reduction in gasoline consumption will require adjustments of catalytic-cracking operating conditions (reduction of reactor temperature and feed contact time with the catalyst) to obtain a higher yield of diesel fuel at the expense of gasoline fractions [redacted]

For some time winter diesel fuel has been in especially short supply, especially in northern regions. This fuel is obtained by increasing the volatility of summer diesel fuel to permit easier combustion in engines operating in cold temperatures. In many instances, the Soviets have been adding gasoline to summer diesel fuel to provide a substitute for winter diesel fuel. This product, however, does not meet the product specifications and reduces the service life of engines in which it is used. [redacted]

Finally, the yield of lubricating oils has remained at a level of about 2.5 percent during the past decade, as the volume of production increased by about 25 percent. Neither the total output nor the quality of lubricating oils produced has been adequate to meet all domestic needs, thus necessitating some imports. The Soviets have long been deficient in producing additives for high-quality lubricants to meet the standards for automotive transport. Despite attempts to correct the problem, it is far from being solved, resulting in continued dependence on imports and efforts to acquire equipment from the West to produce more additives. [redacted]

Current Status of Refinery Capacity and Technology

Primary Distillation

Large distillation units and a concentration of high-capacity plants have marked the development of Soviet refining. For example, the average crude oil charge (primary distillation) capacity of a Soviet refinery in 1984 was about 200,000 barrels per stream day (b/sd), compared with about 75,000 b/sd for a US refinery.[3] [redacted]

Estimates of Refinery Capacity. In mid-1984 the USSR had 50 major refineries in operation with a primary distillation capacity of about 10.5 million b/sd. [redacted] This is a new CIA estimate. It represents a total capacity that is adequate to process the net supply of crude oil as calculated from officially reported production *less* exports, estimated losses, changes in stocks, and field use. The bulk of the information used to derive the capacity figures was [redacted] correlated with data in Soviet technical journals and books that provide sketches and diagrams of typical units with varying design capacities. Reports from emigres who are experts in refining have also been used to verify capacities of various standard units that operate above design capacity. This estimate of primary distillation capacity is slightly lower than the 11-million-b/d estimate currently held by DIA, but it appears to be within the limits of error inherently probable from the use of alternative estimating procedures. [redacted]

25X1 25X1 25X1 25X1 25X1 25X1

[redacted] additional primary distillation capacity of about 440,000 b/sd is under construction at two new refineries—Chimkent and Chardzhou—and at Saratov, where an existing plant is being expanded. The units at Chimkent and Saratov are likely to be on stream in early 1985, and that at Chardzhou in 1986-87. The augmented capacity should enable the USSR to process enough crude oil to meet domestic demand and provide 700,000 to 800,000 b/d of petroleum products for export during the next few years. A rising share of these exports is likely to be heavy fuel oil if the buildup in catalytic-cracking facilities lags as it has in the current five-year plan period. [redacted]

25X1 25X1 25X1

Location of Plants and Concentration of Capacity. Almost 70 percent of total crude oil charge capacity (primary distillation) is concentrated near the major centers of consumption west of the Ural Mountains and north of the Caucasus Mountains (see table 3). In the past, most refineries were built near oilfields in western regions of the USSR, specifically in the Volga-Urals area and in the Caucasus and Caspian Sea regions. The bulk of the country's crude oil was produced in these areas until the 1970s, when output

25X1

[3] This unit of measurement is based on an operating day of a process unit (as opposed to a calendar day). A stream day includes an allowance for regular downtime (see the footnote to table 2). [redacted]

25X1

Page Denied

25X1

from West Siberia increased sharply and production in the older areas began to decline. Many of the refineries in the older oil-producing regions are now processing crude oil from West Siberia to meet needs for petroleum products. In the future, as the eastern regions undergo industrial development and an increasing share of crude oil production comes from the West Siberian fields, expansion and modernization of the four major Siberian refineries are likely. [redacted]

25X1

Some refineries lack the flexibility to provide all of the products needed to meet seasonal demands in their regions. As a result, spot shortages of some products occur, especially in the late summer and early fall when the demand for diesel fuel for the agricultural harvest is at its peak. Shortages of proper grades of fuels and lubricants are chronic in the remote northern areas of Siberia, where important extractive industries are located. [redacted] 25X1

Level of Technology. Soviet developments in primary distillation technology have followed those in the West, but with some lags. (The major types of Soviet equipment used in primary and secondary processing of oil are listed in appendix B.) In the 1950s and 1960s primary distillation units installed at new plants had capacities ranging from 22,000 to 66,000 b/sd. By the late 1960s and throughout the 1970s, primary stills with capacities of 130,000 to 180,000 b/sd were built in new refineries and added to existing plants. According to Soviet emigres, the conservative practices followed by designers of Soviet distillation units have made it possible for refineries to operate these units at rates usually in excess of the design capacities. [redacted]

Plans since the mid-1970s have called for installation of primary distillation units with a capacity of 260,000 b/sd, but we have no evidence that these units have been built. Currently, the Soviets are emphasizing the use of combined processing systems (large primary distillation units and catalytic-processing facilities in tandem). [redacted]

25X1

25X1

Table 3
USSR: Regional Concentration of Petroleum Refineries, 1984

	Primary Distillation Capacity [a] [b] *(thousand b/sd)*	Percent of Total
USSR total	**10,500**	**100.0**
Volga-Urals	**3,440**	**32.8**
Of which:		
Ufa [c]	770	
Gor'kiy [d]	585	
Kuybyshev [d]	570	
European USSR and north	**2,800**	**26.7**
Of which:		
Polotsk	530	
Kirishi	465	
Ryazan'	450	
Siberia and the Far East	**1,440**	**13.7**
Of which:		
Omsk	575	
Angarsk	420	
Caucasus	**1,180**	**11.2**
Of which:		
Baku [d]	620	
Groznyy [c]	400	
Ukraine	**1,020**	**9.7**
Of which:		
Lisichansk	500	
Kremenchug	360	
Central Asia	**620**	**5.9**
Of which:		
Pavlodar	160	
Fergana	160	
Krasnovodsk	130	

[a] Capacity expressed as barrels per stream day (b/sd) is based on the actual period in which the distillation units are operating. This capacity exceeds barrels per calendar day (b/cd) by a factor of about 10 percent because of the normal annual downtime and turnaround time for pipe-still operations.
[b] This total also includes about 90,000 b/sd of topping-plant capacity located at various oilfields in West Siberia and the Volga-Urals region. Although no specific locations are given, reports indicate that some petroleum products for oilfield and gasfield use are obtained from local facilities, not from major refineries.
[c] Three separate plants near city listed.
[d] Two separate plants near city listed.

Note: USSR total and regional subtotals are rounded to three significant digits.

Table 4
USSR: Estimated Capacity of Modern Secondary Processes

Thousand barrels/stream day

	1965	1970	1974	1980	1983
Total	**620**	**1,650**	**2,270**	**2,900**	**3,230**
Catalytic cracking	230	420	460	500	545
Hydrocracking	0	0	0	25	25
Catalytic reforming	200	720	1,040	1,260	1,370
Hydrogen treating	130	290	460	710	830
Delayed coking	60	220	310	405	460

25X1

The USSR relies primarily on its own facilities to manufacture the crude oil distillation units used in its refining industry. Since 1976, however, East Germany reportedly has been supplying the Soviets with primary distillation units with a capacity of 130,000 b/sd that are based on Soviet designs. According to Soviet foreign trade statistics, since the 1970s the USSR has imported a total of 125-190 million rubles' worth of refining equipment annually from East European countries and from a few West European nations, but no data are available breaking down the amounts spent on primary and secondary processing equipment and/or technology. 25X1

Secondary Processing

Secondary processing capacity in the USSR, excluding thermal cracking, is estimated at more than 3 million b/d, equivalent to about 30 percent of total primary distillation capacity (see table 4). In contrast, the capacity of similar types of secondary processing units in the United States is about 120 percent of primary capacity. The far greater demand for light petroleum products in the United States accounts for much of the difference. US automobiles use 45 percent of the crude oil in the form of gasoline, whereas the percentage in the USSR is much less because of the relative scarcity of passenger cars. Nevertheless, the low level of Soviet secondary refining capacity results in sporadic shortages of light fuels and limits the flexibility available to planners for adjusting the product mix in response to seasonal fluctuations in demand. 25X1
25X1

Types of Units on Stream. During the past two decades the Soviets have emphasized installing catalytic-reforming and hydrogen-treating processes for upgrading product quality. At the same time, the Soviets lagged in the addition of catalytic-cracking and/or hydrocracking facilities to reduce the yields of heavy fuel oil and increase the proportion of light distillates (gasoline, kerosene, light diesel fuel) from a barrel of crude oil. The USSR now has a total cracking capacity of about 1.5 million b/sd, of which about 900,000 b/sd consists of thermal cracking and only 570,000 b/sd consists of catalytic cracking and hydrocracking. This level of catalytic conversion represents only 5 percent of the estimated primary distillation capacity. By comparison, the United States has a total catalytic-cracking and hydrocracking capacity of about 6.5 million b/sd, or about 38 percent of current crude oil charge capacity.

The Soviets have had some success in modernizing their secondary units, improving the catalysts used, and increasing the sizes of the newer units installed. For example, several refineries are being revamped to expand feed capacity of individual catalytic-cracking units from 750,000 tons per year (about 17,000 b/sd) to 1.2 million tons (27,000 b/sd), and to convert them to use zeolite catalysts, which can provide gasoline yields of up to 45 percent of the feedstock. New units installed during the current five-year plan have a feed capacity of about 2 million tons per year (about 45,000 b/sd).

Capacities of catalytic-reforming units installed have increased from 300,000 tons per year (7,800 b/sd) to 1 million (26,000 b/sd), and new, more efficient bimetallic catalysts are being used. Hydrogen-treating facilities, used primarily to upgrade the quality of diesel fuel, are being expanded from 900,000 tons per year (almost 19,000 b/sd) to 2 million tons (45,000 b/sd). Delayed-coking units, which provide electrode coke for industry and reduce the yields of residuals, are being designed and built to reach charge capacities of up to 1.5 million tons per year.

The refining industry has employed a variety of technologies in its efforts to build combination systems for "deeper" refining of crude oil at new plants and to replace facilities at older plants. One system being installed to increase the yield of light distillates and reduce the yield of heavy fuel oil (the GK-3) uses vacuum distillation, catalytic-cracking, visbreaking, and gas fractionation units. There are two operating at the Kremenchug refinery in the Ukraine and one at the Angarsk refinery in East Siberia.

25X1

The Soviets continue to allude to a greater-than-planned yield of mazut from refining operations. Considerable publicity is given to the need for additional catalytic-cracking capacity, but the program is lagging badly. The delays in implementing the cracking program probably stem from several factors that affect Soviet oil supply and demand:

- Officials of the Ministry of the Refining and Petrochemical Industry have been led to believe that oil reserves are adequate and that crude oil production goals will be met, thus assuring that the refining industry will be able to meet the demand for light products from current capacity. 25X1

- The failure to substitute coal and natural gas for oil as planned at thermal electric power plants has resulted in a greater-than-expected consumption of mazut and less-than-planned availability for secondary processing.

25X1

- In recent years the USSR has been able to sell several million tons of mazut annually for hard currency in Western Europe, where many refineries have been upgraded and can switch between crude oil and heavy fuel oil as feedstocks; Soviet mazut has been a valuable source of supply from which these sophisticated plants can obtain light-product yields of 70 percent. 25X1 25X1 25X1

We also know from official statements that the Soviet refining industry is having trouble developing and assimilating secondary processing technology. The time required to build and put secondary units on stream far exceeds that for similar units built in the West. 25X1

Although secondary processing capacity is not being increased at a rate that would handle the substantial volumes of mazut planned to be freed by the substitution of gas and coal as boiler fuel, increases in 25X1

25X1

[redacted]

25X1

secondary capacity at the end of the five-year plan period appear to be keeping pace with the slow rate of expansion of primary distillation capacity. By the end of 1985 about 70 percent of the 440,000 b/sd of new primary distillation capacity now under construction is likely to be on stream. The total additional yield of heavy fuel oil from this capacity may approximate 60,000 b/sd in 1985, assuming full operation for the second half of the year. Secondary capacity that has recently been completed or will be in 1985 includes two catalytic-cracking units, a hydrocracker, and two delayed-coking units. These units would have the capacity to process the prospective additional yield of mazut into light products. [redacted] 25X1

The two catalytic-cracking units have a similar design and capacity (45,000 b/sd each) and were completed in late 1983 and early 1984 at the Moscow and Pavlodar refineries, respectively [redacted] One additional catalytic cracker is in the early stages of 25X1

[redacted]

25X1

25X1

construction at the Groznyy refinery but is unlikely to be completed in 1985. [redacted], construction is being stepped up on the hydrocracker at the Omsk refinery, and this unit, with a charge capacity of about 25,000 b/sd, could be operating sometime in 1985 [redacted] The two delayed-coking units, with a feedstock capacity of about 30,000 b/sd each, are under construction at the Kuybyshev and Baku refineries, respectively, and are likely to be completed in 1985. [redacted]

25X1
25X1
25X1
25X1

Level of Technology. The Soviets are aware of Western developments in secondary processing but have been slow to adopt many of these processes in their industry, partly because of the different character of oil-product demand in the USSR. As the need for high-quality light products has increased in recent years, however, the refining industry has been criticized in the Soviet press for failing to provide the necessary equipment and catalysts. Soviet emigres report that difficulties have been encountered in the manufacture of reactors and regenerators for catalytic-cracking and hydrocracking units. The Soviets have had particular problems in meeting the specifications for special alloy steels with high resistance to corrosion. Soviet technical journals also describe numerous operating problems that occur in the USSR's secondary processing units. Catalytic reformers are shut down frequently for repairs; new bimetallic catalysts cannot be used at times because of inadequate removal of salt and sulfur from the feedstock. In the hydrotreaters used for upgrading diesel fuel, poor-quality catalysts are often used; pumps and compressors do not operate properly; the feedstock contains too many light fractions; and the use of excessively high temperatures reduces the volume of throughput. [redacted]

Support From Eastern Europe. The USSR has relied on Eastern Europe for some of its catalytic-reforming and hydrogen-treating units. During the 1960s and 1970s Czechoslovakia supplied 14 complete catalytic-reforming installations for producing high-octane gasoline and 11 diesel fuel hydrotreating units. These facilities, designed according to Soviet technical specifications, reportedly added a total of 27 million tons of secondary oil refining capacity. During the same period, East Germany delivered 16 complete catalytic-reforming units and two diesel fuel hydrotreating facilities. A recent article in the Soviet press indicated that Czechoslovak engineers will assist Soviet specialists in construction at the Groznyy refinery of one of the country's largest hydrotreating units for producing high-quality diesel fuel. [redacted]

Imports From the West. Western firms, especially French companies, have installed a number of complete catalytic-reforming and aromatics extraction units and diesel fuel hydrotreating facilities in the USSR during the last decade. The only known commercial hydrocracking unit operating in the USSR has a capacity of about 1 million tons per year (25,000 b/sd) and was built by a French firm (Technip) at the Ufa refinery in the mid-1970s. The Soviets have attempted to build a similar unit, but with a larger feedstock capacity, at the Omsk refinery in West Siberia. Under construction since 1976, it remains incomplete—although [redacted] work has been speeded up and initial operation could begin in 1985. [redacted]

25X1

25X1

Soviet priorities for expanding secondary processing capacity include the use of Western equipment and technology for hydrocracking, fluid-catalytic cracking, alkylation, and desulfurization processes. The USSR acknowledges that US technology and equipment are the best in the world, but, because of US export restrictions, Moscow is seeking such know-how from non-US firms. Numerous offers have been made to Japanese, French, and Italian companies for purchase of refinery equipment during the past five or six years, but no contracts have been signed to date.

[redacted]

25X1

25X1

Outlook for the Remainder of the 1980s

Primary Capacity

Soviet information on primary refining of crude oil is given only in terms of index numbers. These index numbers show primary refining capacity in 1980 up 67 percent from 1970; in 1985 (planned), up 84 percent from 1970. Using our estimate of primary capacity in 1970 of almost 6.1 million b/sd and applying the Soviet index numbers, the corresponding capacities for 1980 and 1985 would be about 10 million and 11 million b/sd, respectively. Our current estimate for 1984 is 10.5 million b/sd. [redacted] we estimate that primary distillation capacity in 1985

25X1

25X1

25X1

may reach 10.8 million b/sd, slightly less than the capacity obtained by using the 1985 Soviet index number with our 1970 estimate as a base.

If crude oil production levels off and then gradually declines by 1990, there will be no need for an expansion of primary capacity. More likely, a number of small, older units in existing refineries will be replaced by larger, more efficient ones of equivalent total capacity. Therefore, primary distillation capacity in 1990 could well remain at or about the 1985 level of 10.8 million b/sd.

The Soviets have announced that during 1981-85 almost one-third of the new primary refining equipment to be installed will replace obsolescent units to improve performance and efficiency. At the Baku refinery, for example, old distillation units were dismantled in 1981 and replaced by an atmospheric-vacuum distillation unit with a capacity of 120,000 b/d. Other efforts under way to improve distillation operations include installation of additional desalting and dewatering units at existing stills; improvement of heat exchangers, pumps, and condensers; use of more efficient trays in the stills; and better insulation of furnaces to conserve fuel and to provide more heat to the distillation process.

Another logical step would be to build topping plants near oilfields in West Siberia to provide a local source for some of the basic products required there and to eliminate the costly transport of these products from refineries at Omsk, Achinsk, or Angarsk. The savings in transport could be substantial; for example, a diesel-powered drilling rig reportedly consumes three tons (about 23 barrels) of diesel fuel every operating day. Moreover, power plants and construction sites near the oilfields could readily use the products obtained from such topping plants.

Secondary Capacity

Soviet plans for 1981-85 focused on the more economical use of crude oil through development of complex deep-refining systems, development of new catalysts to be used in secondary processing, and increasing the yields and qualities of light products, especially high-octane gasoline and low-sulfur diesel fuel. But—as noted above—the program is far behind schedule. Even if an all-out construction and investment effort were initiated at once, the full complement of conversion units planned for 1981-85 probably could not be put on stream before the end of the 1980s. 25X1

More than 20 units for processing heavy fuel oil, including seven catalytic-cracking and two hydrocracking units, were to be installed in 1981-85. In 1982 V. S. Fedorov, Minister of the Oil Refining and Petrochemical Industry, acknowledged the five-year plan goals but admitted that serious shortcomings—constraints on capital construction and investment, failure to introduce scientific and technological 25X1 achievements, and inadequate methods of control—might limit plan fulfillment. Indeed, our estimate (set out above) is that only two catalytic-cracking units and one hydrocracking unit, the latter under construction since 1976, will be completed by the end of 1985. 25X1

Implications for the Economy

Because the demand for mazut has remained higher than expected, the delay in construction of secondary processing facilities to reduce the yield of mazut has not had serious short-term consequences. In the longer run, however, these delays may result in constrained availability of light products from domestic refineries. We anticipate that the demand for light products in 25X1 1990 will be some 1 million b/d higher than in 1980, but only about 90,000 b/sd of catalytic-cracking capacity has been added since 1980. 25X1

As Soviet refiners attempt to step up residual conversion to increase the supply of light products during 1986-90, they have several options available to solve their secondary processing dilemma. The USSR could undertake a priority program of importing turnkey cracking facilities from the West. Such a program could get the job done more rapidly and efficiently than relying on domestic manufacturing plants, which 25X1 have not been dependable in supplying the necessary equipment. But Western equipment and technology would require large outlays of hard currency. For example, the capital cost of a fluid catalytic cracker with a feed charge capacity of 22,000 b/sd is about $50 million, and a hydrocracker with the same charge

capacity is about $70-80 million. The installation of 15 catalytic-cracking units—or a combination of catalytic-cracking and hydrocracking units—to meet the need for light products by 1990 would require a capital investment of at least $1 billion. [redacted] 25X1

Alternatively, the Soviets could install relatively unsophisticated thermal units—thermal crackers, visbreakers, delayed cokers—to increase the yield of light products by treating residual feedstocks. However, the yields of the desired light products would be lower than those obtainable from the catalytic-cracking and hydrocracking processes, and the products would have to be upgraded by the use of hydrotreating and catalytic-reforming facilities. This alternative—though slightly less expensive and possible to implement with indigenous equipment—is less efficient. [redacted] 25X1

A combination of options might be more attractive to the Soviets: to buy one or two catalytic-cracking or hydrocracking units from the West and also use the aforementioned secondary units to convert residuals to lighter products. At the same time, constructing domestic catalytic-cracking units and importing catalytic reformers and hydrotreaters from Czechoslovakia and East Germany would continue to improve the technological base for upgrading fuel quality. [redacted] 25X1

If the buildup of secondary processing facilities were inordinately delayed, the Soviets, in the short run, could opt to export more crude oil and import from the West the incremental volume of high-quality light petroleum products that they might require for domestic use. This option, however, is inconsistent with Moscow's predilection for reducing dependence on the West, especially in view of the importance of the light products for use by the military, agriculture, and commercial transport. Furthermore, such imports would use hard currency needed for other purposes and would clog an already congested rail network. [redacted] 25X1

Whatever choice the Soviets make, implementation will be time consuming and expensive. Some Western involvement would almost certainly be necessary to obtain a fuel mix compatible with achieving a relatively rapid shift in energy consumption, replacing oil with gas and coal in major uses. [redacted] 25X1

Appendix A

Glossary of Major Refining Processes

Primary

Primary distillation—The first step in refining, which achieves a rough separation of petroleum constituents in some form of closed apparatus by the application of heat at atmospheric pressure.

Vacuum distillation—Separation of heavier fractions of crude oil under reduced pressure; the boiling temperature is thereby reduced sufficiently to prevent decomposition or cracking of the material being distilled.

Topping plants—Small units where distillation is used to remove light fractions (gasoline, kerosene, diesel fuel) for local use.

Secondary

Secondary processing—General category for refining of various oil fractions after primary distillation to provide a higher yield of the lighter products and to upgrade product quality.

Thermal

Thermal cracking—A refining process that decomposes, rearranges, or combines hydrocarbon molecules by the application of heat without the aid of catalysts. The major variables involved are types of feed, time, pressure, and temperature. In general, heavier fractions are easier to crack than lighter ones; yields of light products increase with an increase in the time of reaction; pressures are generally low (from 50 to 350 psi) to retain the heavier molecules in the zone of cracking at the temperature of decomposition, ranging from 370°C to 590°C.

Visbreaking—A comparatively mild once-through thermal cracking process used to reduce the viscosity and lower the boiling range of heavy residual stocks. The process has a low capital cost, but it is the least efficient for reducing fuel oil production. The products obtained are of poor quality and must be hydrotreated.

Delayed coking—A semicontinuous severe thermal cracking process for the conversion of heavy oil fractions into lighter material. Feedstock is preheated to 480°C to 510°C in a pipe still, discharged into large insulated coke drums, and held there at temperatures around 430°C under low pressures (10 to 70 psi) while cracking takes place. Gas, gasoline, and gas oil are obtained as overhead products, and coke is recovered from the drums. This coke can be used as an industrial fuel or, when purified, can be utilized in the production of electrodes for the aluminum industry.

Catalytic

Catalytic cracking—Conversion of high-boiling-point hydrocarbons into lower boiling ones by means of heat and a catalyst that may be used in a fixed bed, moving bed, or fluid bed. In the process, oil vapors are heated to about 540°C in the presence of a catalyst at low pressures (10 to 20 psi) in a reactor. The heavier oil

fractions crack into lighter ones (gasoline and distillate fuels) that are then sent to a tower for distillation. The used catalyst goes to a regenerator where it is reactivated for further use by burning off the carbon (coke) deposited on the catalyst in the cracking process.

Hydrocracking—Conversion of high-boiling hydrocarbons into lower boiling ones by the use of heat and a catalyst with the addition of hydrogen. It is an efficient, low-temperature (200°C to 430°C), high-pressure (100 to 2,000 psi), catalytic process for converting middle-boiling or residual stocks to high-octane gasoline, jet fuel, or high-grade fuel oil.

Catalytic reforming—Rearranging of hydrocarbons in a gasoline-boiling-range feedstock using heat (430°C to 540°C) and pressure (50 to 750 psi) in the presence of a catalyst to increase the octane rating, or to produce aromatic hydrocarbons—benzene, toluene, xylenes—for petrochemical uses.

Hydrogen treating—A process to stabilize petroleum products (ranging from naphtha to reduced crude oils) and/or remove impurities from products or feedstocks through a reaction with hydrogen in the presence of a catalyst. When the process is used specifically for sulfur removal, it is usually called *hydrodesulfurization.*

Alkylation—A process of combining light hydrocarbon molecules (ethylene through pentene with isobutane) in the presence of sulfuric acid or hydrofluoric acid to form high-octane blending components for the production of motor gasoline.

25X1

Appendix B

USSR: Catalogue of Major Units Used in Primary and Secondary Refining of Oil [a] [b]

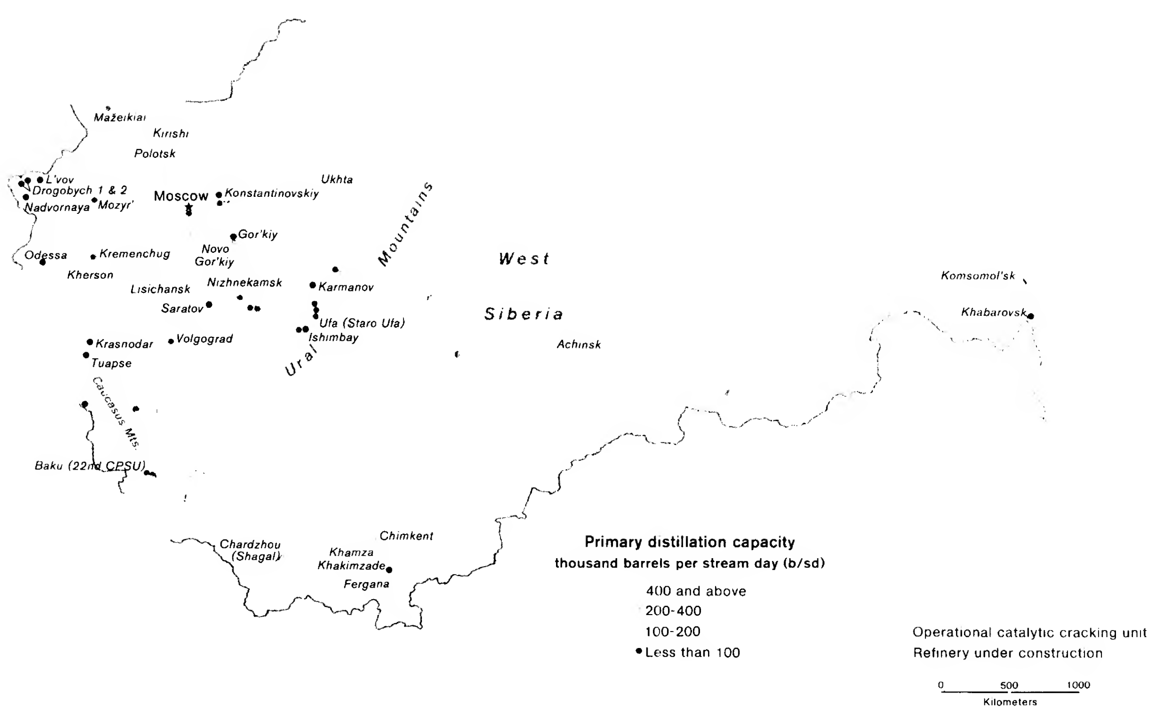
Unit	Designation	Feedstock Capacity (*thousand tons per year*)
Primary		
Electric desalter	10/1	600
	10/6	2,000
Atmospheric-vacuum pipe still (AVT)	12	600
AVT with crude oil desalter	A-12/1	1,000
	A-12/2	2,000
	A-12/3	3,000
	ELOU-AVT-6	6,000
AVT with redistillation of gasoline	A-12/6	3,000
	A-12/9	3,000
AVT with desalter and redistillation of gasoline	13/1	6,000
Vacuum distillation of mazut	NA	3,000
Secondary		
Thermal cracking	15/5	450
Delayed coking	21-10/3	600
	21-10/9	600
	NA	1,500
Diesel fuel hydrotreating	L-24/5	900
Fuel hydrotreating	Lch-24-2000	2,000
Catalytic reforming	L-35/5	300
	L-35/6	300
	L-35/11/300	300
	L-35-11/600	600
	L-35-13/300	300
	Lch-35-11/600	600
	L-35-11/1000	1,000
Secondary (continued)		
Catalytic cracking	43-102 (granular catalyst)	250
1A/IM (powdered catalyst)	NA	600
G-43-107 (zeolite catalyst)	NA	2,000
Alkylation (sulfuric acid)	25-6	90
Combination unit for nondeep processing of oil	LK-6u	6,000
Combination unit for deep processing of oil	GK-3	3,000
Residuum deasphalting	36-1	250
Asphalt production	19-1	125
	NA	750
Coke calcining	NA	140
Lubricant processing		
Phenol treating of lubricating oils	37	265
Furfural treating of lubricating oils	G-37	600
Dewaxing of lubricating oils	39-7	250
Contact treating of lubricating oils	41-1	330

[a] Rudin, M. G., Smirnov, G. F., *Proyektirovaniye neftepererabotyvayushchikh i neftekhimicheskikh zavodov* (Planning Oil Refining and Petrochemical Plants), Khimiya, Leningrad, 1984, pp. 66-67.
[b] *Khimiya i tekhnologiya topliv i masel,* No. 10, 1979, p. 10.

25X1

Sanitized Copy Approved for Release 2011/01/31 : CIA-RDP86T00591R000200190003-0

Figure 3
Capacity of Soviet Oil Refineries



25X1

704671 (A05056) 4-85